

***Generation Interconnection
Feasibility
Study Report***

For

***PJM Generation Interconnection Request
Queue Position W2-096***

West Carlisle-Newville 1 69kV

October 2010

Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

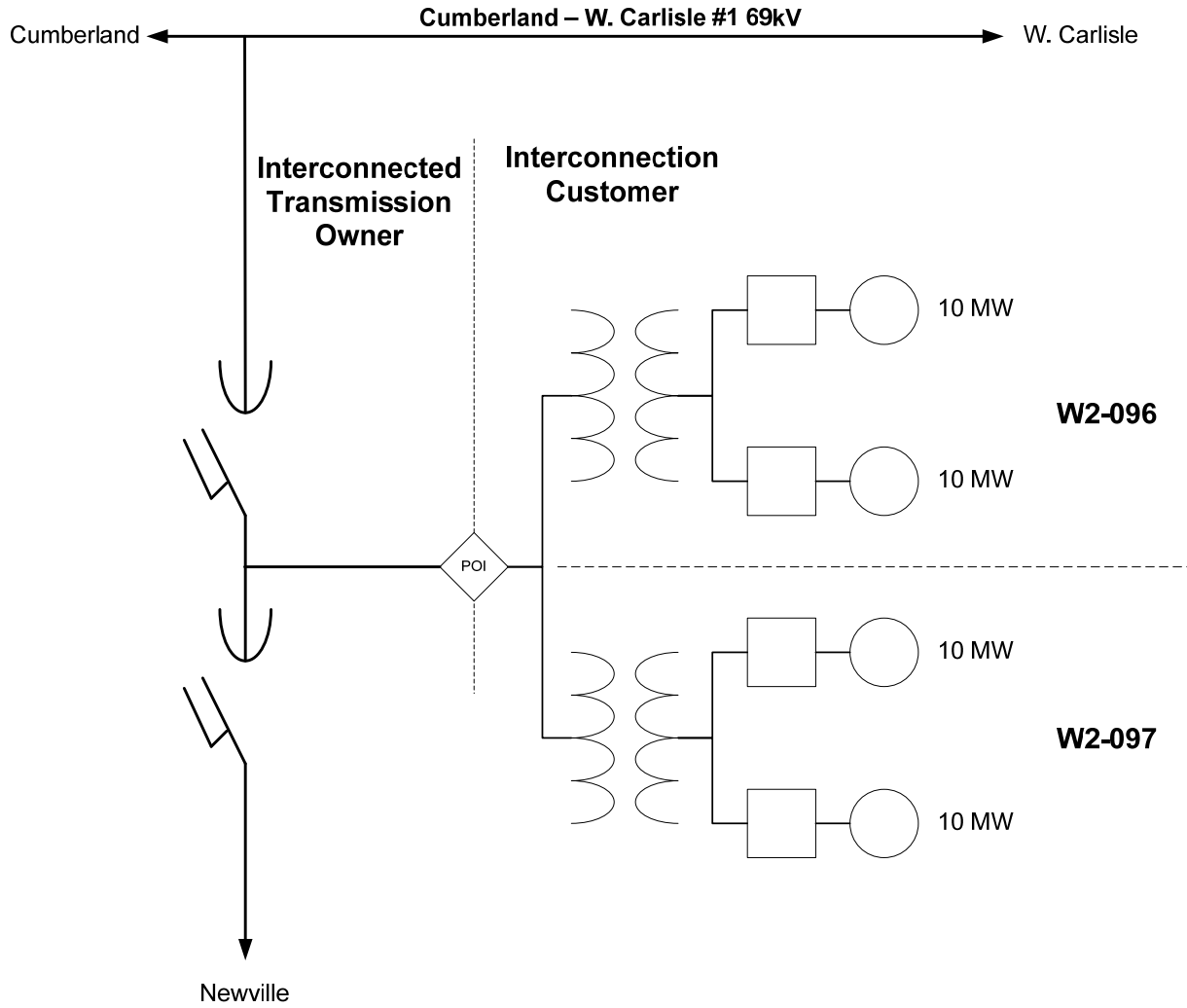
General

Queue W2-096 is an (IC) request to interconnect a 20 MW Energy (7.6 MW Capacity) Solar PV Generating Station, with ground mounted fixed panel solar arrays. The capacity portion of 7.6 MW means that the remaining 12.4 MW will be curtailable should a system reliability constraints occur. Queue W2-096 is located in W. Pennsboro Township, Cumberland County, PA. Queue W2-096 generation interconnection desires commercial operation by June 1, 2012. **This study does not imply a PPL EU commitment to this in-service date.**

Point of Interconnection

Queue W2-096 can be connected to PPL EU's 69 kV Transmission System by tapping the Newville 69kV line off of Cumberland - W.Carlisle #1 line. The W2-096 substation would be connected to the Newville 69kV tap line via a short tap as shown in Figure 1.

Figure 1



Transmission Owner (PPL EU) Scope of Direct Connection Work

The total estimated cost of Direct Connection Facilities needed to connect Queue W2-096 to the Newville 69 kV tap is:

\$665,000 (Transmission Cost) + (Substation Cost) (excluding any applicable state or federal taxes).

The 69 kV connection estimate is based on the assumptions stated in the following Transmission and Substation Direct Connection Work sections. This estimate may vary depending upon the Queue W2-096 substation location and orientation.

The transmission and substation costs given above exclude any applicable state or federal taxes. If at a future date Federal CIAC (cost in aid of construction) taxes are deemed necessary by the IRS for this project, both PJM and PPL EU shall be reimbursed by the Interconnection Customer for such taxes.

A further breakdown of the direct connection costs are as follows:

\$	402,000	New 69 kV tap to W2-096 and LSAB switches on the Newville tap
	5,000	Review of Siting/ROW for new 300ft 69 kV tap to W2-096
	258,000	Cumberland 230/69 kV Substation work to accommodate W2-096
<hr/>		
\$	665,000	Total Direct Connection

The time required for siting and Right-of-Way review/requisition is estimated to be 3-6 months assuming W2-096 is the only landowner involved and is willing to provide the necessary Right-of-Way. This work could take longer than expected if W2-096 is not the only landowner involved or if any unforeseen litigation takes place. The typical time needed to complete the transmission tap design and construction work is estimated to be approximately 12 to 15 months. All Rights-of-Way will need to be acquired prior to the start of construction. The substation work may require approximately 9 to 15 months and can be completed simultaneously with the 69 kV tap construction. This translates into a **12 to 18 month** project time frame for the direct connection work.

After the PJM three-party Interconnection Service Agreement (ISA) and Construction Service Agreement (CSA) are signed and PPL EU receives written authorization by PJM to begin work, PPL EU will commence the siting, engineering design, material purchase, and construction of facilities identified above.

69 kV Transmission Tap Direct Connection Work

\$	402,000	New 300 ft. 69 kV tap to W2-096 and LSAB switches on the Newville tap
	5,000	Review Siting/ROW for new 300 ft. 69 kV tap to W2-096
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\$	407,000	Total Transmission Direct Connection Work

The transmission direct connection work includes tapping the Newville 69 kV tap and from there building a tap connection using 556.5 Kcmil ACSR conductors with ½” EHS overhead ground wire (OHGW) using two Light Duty guyed steel poles to a dead-end structure in the new W2-

096 customer-owned substation. The tap line will be a 69 kV steel pole design. In addition to the tap, two LSAB (Load Sectionalizing Air Break) switches would be installed on the PPL EU Newville taps on both sides of the IPP W2-096 tap for the isolation of W2-096 tap. The switches would be installed on the custom designed steel poles with concrete foundations. The estimated cost of the transmission tap and the LSAB switches work is \$402,000 and is included in the above estimate.

The transmission cost estimate does not include the cost to site and acquire a 100 ft. wide right-of-way from PPL EU 69 kV tap to IPP W2-096 dead-end structure. Per the developer supplied information, the 100ft wide R/W would be available on the customer owned property. **The tap will be designed and operated at 69 kV and will therefore not require PUC certification. PUC certification is required only on overhead transmission lines built with 100kV and above.** Only a review of R/W will be undertaken with a cost of approximately \$5,000 and is included in the above estimate. See attached figure 2 for schematic of the connection.

The estimate does not include costs to litigate or mitigate extraordinary environmental impacts. This estimate was made under the assumption that the necessary Rights-of-Way are owned by the IPP W2-096.

The lead time required for the transmission line direct connection work is approximately **12 to 18 months** (3-6 months for the siting/right-of-way review and 12 to 15 months for the transmission engineering/construction work, where both can be done concurrently). This estimate assumes that suitable line outages can be scheduled as required to terminate the new tap onto the existing Newville tap. Failure to meet a scheduled line outage may result in project delays. All rights-of-way must be acquired or available prior to the start of construction of the new transmission tap.

Substation Direct Connection Work at Cumberland 69 kV Source Substation

\$ 258,000 Total Substation Direct Connection Work to accommodate W2-096

To accommodate W2-096, the following upgrades are required at PPL EU's Cumberland 69 kV Substation.

- Install one telephone line based Direct Transfer Trip (DTT) Cabinet
- Install new telephone line protection equipment
- Install a Synch Check Relay on the W. Carlisle #1 69kV circuit breaker
- Modify the controls for the W. Carlisle #1 69kV Circuit breaker for trip and close
- Modify SCADA for new alarms
- Modify AMS (Alarm Management system)
- Install new cables and modify control wiring for the above
- Perform system checks and test equipment before placing in service

This work includes installation of phone line based DTT equipment and control design modifications for the W. Carlisle #1 69kV circuit breaker at the PPL EU Cumberland Substation. W2-096 will be required to provide a matching set of DTT equipment at their site. The scheme will provide a trip signal to W2-096 for any line fault, or any other condition that will cause the

PPL EU W.Carlisle #1 circuit breaker at Cumberland substation to trip or open or any other condition that will result in the formation of an island. This trip signal to W2-096 will be maintained for as long as the PPL EU breaker at Cumberland substation remains open or the island condition exists. No automatic reclosing of the Interconnection Customer's isolation breaker will be permitted.

Once the Interconnection Customer's isolation breaker is open, a return signal via the W2-096 DTT set will be sent to PPL EU Cumberland breaker indicating that the W2-096 Isolation breaker is open. This return DTT signal will permit PPL EU Cumberland circuit breaker to close in an attempt to reenergize the line. If the line is successfully reenergized and the other customers loads connected to this line are picked up, the W2-096 generation can restart and reconnect it to the PPL EU system.

The W2-096 DTT scheme also provides a block-closing signal to the breaker at Cumberland to block Carlisle#1 breaker auto reclosing until W2-096 breaker has tripped or any W2-096 generation is on line.

The estimated total cost for the work at Cumberland Substation is approximately **\$258,000** and is included in the above estimate.

The lead time required for the substation direct connection work is approximately **9 to 15 months**. This schedule assumes that suitable line/equipment outages can be scheduled as required. Failure to meet a scheduled line outage may result in project delays.

Preliminary PPL EU Direct Connection Work Schedules

The estimated PPL EU elapsed time to complete the 69 kV direct connection transmission tap and the substation upgrades is approximately **15 to 18 months** after the receipt of a fully executed ISA/CSA.

The schedule for the 69 kV transmission and substation work to accommodate W2-096 would depend on the project start date. The work to accommodate W2-096 will require transmission line outage. PPL EU's outage windows for construction are typically available in the spring and fall of the year. Missing an outage window could result in project delays.

Assumptions and Notes

- Long lead-times for leased telephone lines may be encountered. Therefore, the W2-096 Interconnection Customer should investigate as soon as possible the availability of leased telephone facilities to meet its in-service schedule.
- For the custom-designed steel transmission poles, the current lead-time is approximately 20 to 28 weeks. It is estimated that two custom designed steel poles will be needed for this project.

- During construction, if extreme weather conditions or other system safety concerns arise, field construction may need to be rescheduled, which could possibly impact the schedule plan.
- Excepting any operational, governmental and/or environmental regulatory delays, the use of additional resources, such as overtime, premiums for expedited material, and/or contractor labor, may enable PPL EU to decrease this construction period. It is also assumed that all rights-of-way and easements are secured without impact on anticipated construction start dates.
- PPL EU recommends that an Interim ISA be completed during the Facilities Study stage to address critical path items, such as long lead-time purchases and any other compressed project schedule issues.
- The ISA/CSA or an Interim Interconnection Service Agreement (IISA) must be signed by the W2-096 Interconnection Customer, PJM, and PPL EU before any PPL EU design and construction activities may commence.

Interconnection Customer Scope of Direct Connection Work

Queue W2-096 Interconnection Customer will be responsible for the construction of all generating station facilities on the W2-096 side of the POI (Point of Interconnection) as shown on Figure 1 on the previous page.

Telephone Circuit Requirements

PPL will require a communication path between the W2-096 customer substation and PPL EU's Cumberland Substation for Voice, SCADA, and DTT.

For the telephone communication path, the Interconnection Customer will be responsible to procure the following:

- a) A protective relay-grade telephone circuit for the DTT communication requirements, type PRDA.
- b) A 4-wire dedicated FDDA-type phone line for SCADA.
- c) A normal dialup telephone line for voice communication.

The DTT phone line will originate at the W2-096 Substation and terminate at PPL EU Cumberland Substation. The SCADA phone line will go to one of our Service centers, to be determined during the Impact or Facility study. Phone lines tend to be long lead-time items and must be in place and operational for DTT equipment testing. Therefore, once the preferred communication path is known, the Interconnection Customer should secure the necessary phone lines as soon as possible.

All installation, maintenance, and monthly lease or billing charges for communications facilities for DTT, metering, etc., are the responsibility of the Interconnection Customer.

Intertie and POC Protective Relaying Equipment

The Interconnection Customer will need to install suitable protection and control equipment based on PPL EU parallel generation requirements. This includes both Intertie Protective Relaying (IPR) and Point of Contact (POC) relaying. Please refer to the PPL EU web site for the IPR and POC requirements. The website addresses are shown below:

IPR Requirements:

<http://www.pplelectric.com/Business+Partners/Tools+and+Reference+Center/Customer-Owned+Generation/>

POC Requirements:

http://www.pplelectric.com/NR/rdonlyres/B0937C7E-B6E9-40AD-AE8C-ED3C9558E528/0/point_of_contact.pdf

DTT Equipment Requirements

Telephone line based audio tone DTT (Direct Transfer Trip) equipment will be required to communicate circuit breaker tripping and status monitoring between the W2-096 and PPL EU Cumberland Substation. (See 'Telephone Circuit Requirements' section of this Study for details on phone circuit requirements). This telephone line would originate from the W2-096 Substation and is a special dedicated 4 wire analog telephone line, type PRDA.

PPL EU will need a signal from W2-096 that will indicate:

- The W2-096 isolation breaker is open (a breaker 'b' switch) or
- A contact that will indicate when ANY inverter is operating in parallel with the PPL system (contact is OPEN when any inverter is in parallel and W2-096 system normal) - this contact will close when ALL inverters are OFF line (disconnected from the PPL system).

PPL EU SCADA Equipment Requirements

PPL EU will require installation of PPL EU approved SCADA equipment that will connect to its existing SCADA system to provide real time values of KW, KVAR, and kV metering data at the POC. Scada equipment will also provide capability to trip and the status monitoring of the POC isolating circuit breaker. In addition to that monitoring of other abnormal conditions at developer's plant will be provided where deemed necessary. This connection will be a 4-wire dedicated FDDA-type phone line. PPL EU will provide detailed specifications and design drawings for this equipment.

Revenue Metering Equipment Installation at the Point of Interconnection

Installation of revenue grade Bidirectional Metering Equipment will be required at the Queue W2-096 Point of Interconnection (POI) to measure KWh and KVARh. PPL EU will design and supply the required metering equipment but all the installation cost would be borne by the developer including CT/PTs. All metering equipment must meet applicable PPL EU tariff requirements as well as being compliant with all applicable requirements of the PJM agreements. The equipment should be housed in a control cabinet or similar enclosure and must be accessible to PPL EU metering personnel.

PJM SCADA Equipment Requirements

Interconnection Customer is also required to provide real-time (instantaneous) values of KW and KVAR data to PJM via the Scada equipment in compliance with the requirements listed in PJM Manuals M-01 and M-14D available at <http://www.pjm.com>

Isolation Breaker Requirement at the Developer's Substation

Per the customer drawing CUM1-OL-01RB, the customer has provided an high side circuit breaker at 69kV with a manual disconnect switch on the PPL EU line side of this breaker, unless

otherwise indicated it is assumed that this be will be the "Isolation Circuit Breaker" and will be operated by the IPR relay and the DTT signal.

Intertie Requirements from the Developer of IPP W2-096

W2-096 Inverter and GSU modeling Data (incomplete, need more information)

Per the W2-096 supplied data (Dwg. CUM1-OL_01RB), the following was used in modeling the inverter and GSU:

W2-096 Inverter Units:

Inverters: 80, 260kW each solar inverters PV powered packaged in PowerVault Model MV-1040KW, 20.8 MW Gross, net injected into PPL EU system 20 MW

Note: All inverters to be used for connecting generation to the PPL EU system are required to be certified to UL1741 and IEEE 1547. The term certified is understood to indicate that the device has been tested to meet the above standards by a nationally recognized testing laboratory. Any inverter not meeting a nationally recognized testing laboratory certification will either not allowed to connect to PPL EU system or will be required to install additional suitable external protection equipment to maintain the same level of system protection.

The inverter supplier must provide upon request copies of the certification of inverter equipment testing by a nationally recognized testing laboratory, self certification or certification by a third party that is not listed on the OSHA web site will not be accepted.

GSU:

Inverter Step Up Transformers: Twenty (20) 0.48/12.47 kV, 1 MVA each transformers with 5.5% impedance at 1 MVA with Delta (480 Volt) and Wye (12.47kV) winding configuration.

Intertie Transformers:

Intertie Step-up transformer: One 69/12.5 kV, 12/16/20 MVA

Impedance-**unknown**

MVA base-**unknown**

The W2-096 Interconnection Customer must provide PPL EU and PJM with the intertie transformer test reports and a model of the inverters once they are available in order to perform a more detailed short circuit analysis.

W2-096 Generator Harmonic and Flicker Requirements

On the PPL EU 69 kV system, the total harmonic distortion to the fundamental voltage wave from a single customer is limited to 1.5% of nominal. In addition, no individual harmonic component can exceed 1.0% of the fundamental system voltage.

If PPL EU discovers that objectionable harmonics in excess of the stated limits are being injected into the system from W2-096's equipment, the Queue W2-096 Interconnection Customer will be responsible for taking corrective measures to mitigate harmonic currents.

Concerning voltage flicker, the W2-096 customer must limit the severity of their voltage variation to within a level which will not cause objectionable flicker to other customers. A voltage drop greater than 5% at the point of interconnection is generally not acceptable. The frequency and severity of the voltage variation must be considered when determining whether a customer's equipment is violating PPL EU flicker guidelines. PPL EU uses the General Electric flicker-irritation curve as a guideline to determine if the system is operating within acceptable limits. PPL EU will require corrective actions by the W2-096 customer if their operation causes flicker that exceeds PPL EU guidelines. One such correction could be the installation of static var compensators (SVC) to hold a constant voltage.

W2-096 Inverter Regulation or Reactive Supply Requirements

As specified in Interconnection Service Agreement, Appendix 2, Section 4.7.1.1 of the PJM OATT (Open Access Transmission Tariff), the W2-096 generator shall design its Facility to meet the following power factor requirement:

“For all new wind-powered and other non-synchronous generation facilities, if determined in the system impact study to be required for the safety or reliability of the Transmission System, the Generation Interconnection Customer shall design its Customer Facility with the ability to maintain a composite power delivery at continuous rated power output at a power factor of at least 0.95 leading to 0.95 lagging.”

This indicates that the interconnection customer must maintain a composite power factor at the point of interconnection in between .95 leading (absorbing 6.6 MVARs) or .95 lagging (supplying 6.6 MVARs). If this capability can not be met, the W2-096 project must provide a STATCOM or SVC device at its substation.

PPL EU preliminary load flow studies have indicated that the W2-096 project would require to operate at .95 pf leading that is absorbing vars from the PPL EU system. If this operation can't be tolerated by the inverters then an SVC would be required to maintain the required voltage regulation on the Cumberland-W.Carlisle #1 69 kV line and the Newville 69kV tap line within its required range.

W2-096 will need to verify from PowerVault that its inverters can adjust to the required power factor range or purchase inverters that can. In future studies, PPL EU will calculate and issue a table of MW versus MVAR for various levels of generation output. Further, W2-096 must provide details on how these requirements will be met at the PCC (the 69 kV point of common coupling). Most inverters monitor to their output terminals, in this case 480VAC, but the voltage, frequency, and power factor must also be monitored at the 69 kV level.

Direct Connection Issues Impacting the Interconnection Customer

Alternate Outlet for Generation Operation during PPL EU Maintenance

No alternate outlet for the generation will be available since nearest second line is approximately 10 miles away. W2-096 will not be able to generate power during PPL EU Newville tap maintenance/outage, or maintenance/outage on the Cumberland-W. Carlisle #1 line, or some times during certain 69kV bus outages at the PPL EU Cumberland 230/69 kV Substation.

Distribution Service Requirements

The Interconnection Customer must submit a request for electric service through PPL EU's Industrial and Commercial Services (ICS) group if the W2-096 solar park requires back-up electric service at a voltage less than 69 kV. The ICS Help Desk can be reached at 1-888-220-9991. Cost for distribution electric service is NOT included in the PPL scope of work transmission or substation estimates below.

Load Shed Scheme at PPL EU Cumberland Substation

PPL EU has two load shed schemes at the Cumberland 69kV substation which operate under some unusual system conditions to trip the Cumberland - W. Carlisle#1 69kV line (along with some other 69kV lines) to maintain system integrity. Since Newville 69kV tap to which the Interconnection customer's generation is connected, is supplied from Cumberland-W. Carlisle #1 line, it will also be tripped and the W2-096 generation will be off line for the operation of load shed schemes.

PPL EU phase rotation at 69kV

PPL EU 69kV phase rotation in this region is CBA and will require connection of transformer high bushings in a certain way. Pleaser refer to the below mentioned POC document for phase rotation and transformer connection requirements.

POC Requirements:

http://www.pplelectric.com/NR/rdonlyres/B0937C7E-B6E9-40AD-AE8C-ED3C9558E528/0/point_of_contact.pdf

Future Conversion of Newville tap to 138kV from 69kV

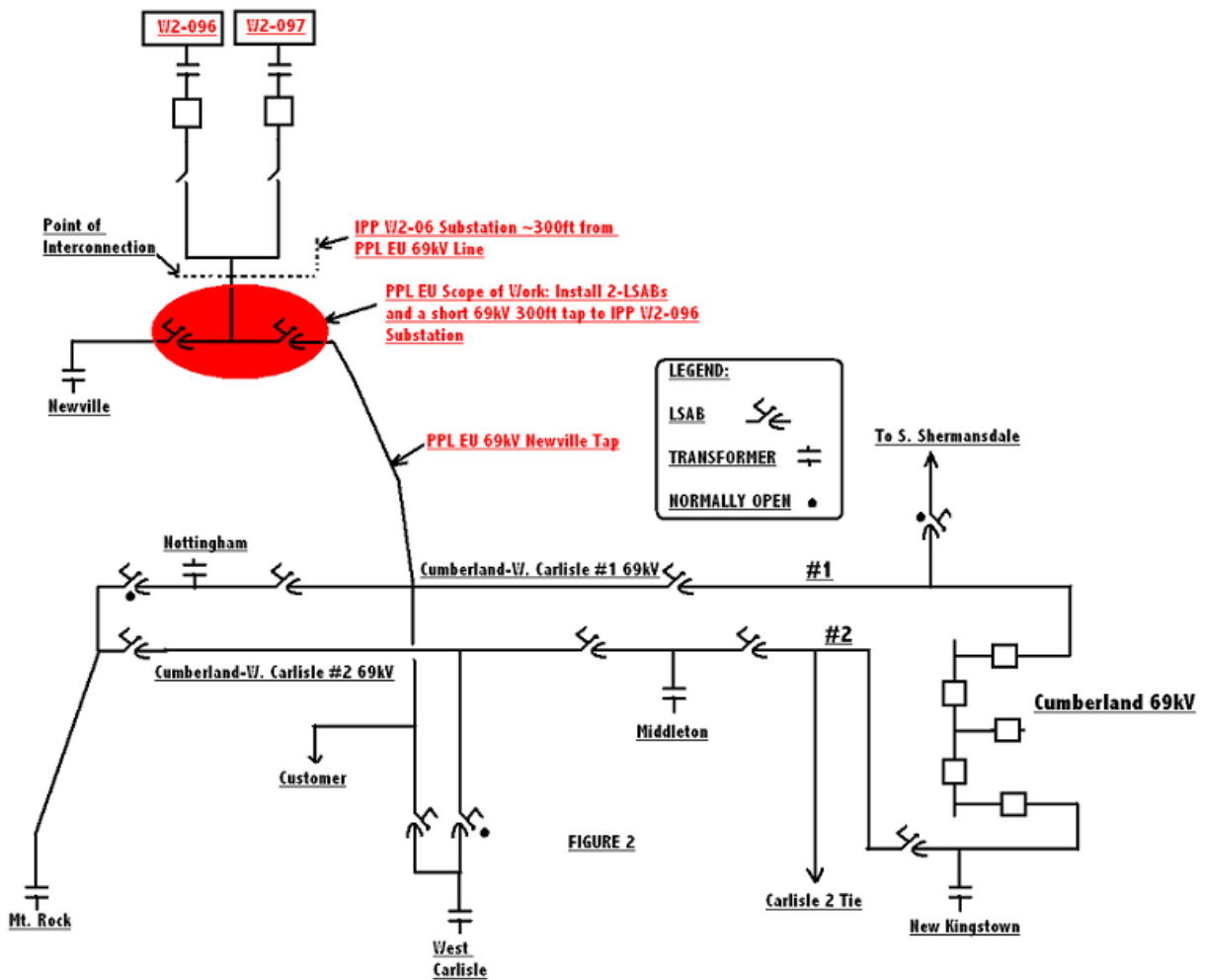
PPL EU presently has no plans to convert this tap to 138kV Voltage in the next 20 years but after that if the area is converted to 138kV system, conversion of the Interconnection Customer's substation to 138kV would be at his cost.

Intertie 69/12kV Transformer Turns Ratio

PPL EU typically procures the transformers with the following high side (69kV) taps:

70.6kV, 68.8kV, 67.0kV, 65.2kV, 63.4kV with nominal mid point voltage is 67kV, this provides a range of 5% above (in two 2.5% steps) and 5% below (in two 2.5% steps) to the mid point range of 67kV. The PPL 69kV system is operated at around 67.9kV at the PPL EU Cumberland substation.

PPL EU typically procures the transformers with the following low side (12kV) taps: 13.2kV fixed



PJM Analysis and Network Impacts

Queue project W2-096 was studied as a(n) 20.0MW (7.6MW of which was Capacity) injection into PPL's system at a tap point along the Carlisle – Newville 69kV line. Project W2-096 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line Contingencies only with full energy output. Stuck Breaker and Bus Fault contingencies will be applied during the Impact Study)

No problems identified.

Contribution to Previously Identified Overloads

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have % allocation of cost responsibility which will be calculated and reported for the Impact Study.)

No problems identified.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of this project generation)

None.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

Short Circuit

(Report Overdutied breakers here)

Not required.

Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of the surrounding generation. Any potential problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the overloaded element(s) identified. As a result of the aggregate energy resources in the area, the following violations were identified.

No problems identified.